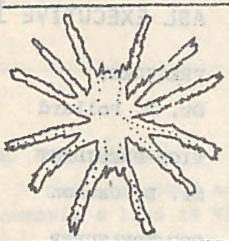
NEWSLETTER

PRIVATE CIRCULATION VOLUME 14 NUMBER 2 SPRING 1976



AUSTRALIAN SOCIETY FOR LIMNOLOGY
NEWSLETTER

VOLUME 14 NUMBER 2 SPRING 1976

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THE AUSTRALIAN SOCIETY FOR LIMNOLOGY

The Australian Society for Limnology is an association of over 200 people with professional or amateur interests relating to Australian inland waters. Since its inception in 1961, the Society has played an important role in fostering limnological work in this country. The ASL also promotes liaison between limnologists in academic, private, and governmental institutions, and has a vested interest in the conservation of aquatic and related resources. Annual congresses are held near centres of limnological interest, and the program includes scientific sessions, field excursions, and social activities.

The ASL produces a Newsletter, with notes on activities, articles of general interest, book reviews, and congress anouncements, and an occasional Special Publication. A further periodical publication is the Directory of Australian Limnologists.

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NOTE: Members are entitled to receive the *Aust. J. mar. Freshwat. Res.* at a reduced rate ($4).

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Details are available from:

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* * * * *

Newsletter contributions are always welcome, and correspondence should be addressed to the Newsletter Editor. The next copy deadline is March 1, 1977.

NEWS

DR. P.S. LAKE:-

Sam has moved across to the Zoology Department, Monash University. Tasmania's loss is Victoria's gain.

RICHARD MARCHANT:-

Richard has gone to Canada (January 1977) to take up an offer of a postdoctoral fellowship with Professor H.B.N. Hynes, Department of Biology, University of Waterloo. His Ph.D., concerned with the energetics of *Parartemia zietziana*, was completed in November 1976.

DR. JOHN LUND:-

John Lund of the Freshwater Biological Association, U.K., was in Australia recently (December). He was here as an advisor to Binnies (Engineering Consultants) who are providing management advice for the A.C.T. regional basin study.

DR. P.A. TYLER:-

The Tyler has been to Macquarie Island yet again!

W.D. WILLIAMS:-

Bill has recently been appointed to the Australian Water Resources Council Research Advisory Committee.

CHAOBORIDAE:- request for material

Dr. Don Colless, Division of Entomology, C.S.I.R.O., Canberra, is working on a review of the Australian Chaoboridae and needs material from the southern half of the continent. Live larvae for rearing would be especially useful.

ARTICLES

THE CHEMICAL ENVIRONMENT IN IMPOUNDMENTS*

By R.T. Buckney

(Department of Zoology, University of Adelaide)

Abstract

The seasonal changes of chemical conditions in water bodies are controlled largely by water movement. Many flowing waters display a logarithmic relation between water discharge and ionic concentration for most of the year. Flood flows and the first discharges after long dry periods are irregular in this regard, so the autumn period may be one of substantial chemical change, particularly in deep, stratifying reservoirs which may be overturning at that time.

The near-cessation of flow in impoundments may have an important bearing on total nutrient levels since these can be precipitated with the particulate material.

These features are illustrated with data for some Tasmanian and South Australian waters and for some experimental treatments.

Introduction

Much of the chemical data available for impoundments has been collected for management purposes. There have been many studies on stratification, eutrophication and water quality of impoundments. Little has been done on the broader aspects of chemical conditions in impoundments.

A recent analysis of chemical variability of inland waters (Buckney 1976) indicated that climatic variability was easily the most important determinant of chemical variability - particularly of salinity changes, and that morphometric characteristics of water bodies were also relevant to a consideration of this topic - large water bodies tend to be less variable than small ones with similar climatic influences. Arid climates tend to have more saline waters which are in turn more variable than fresh waters characteristic of humid areas. Of the climatic elements, water discharge is a major factor influencing the concentration of dissolved constituents in stream water (Edwards 1973). It has been shown that streams often display a clear relationship between discharge and the concentrations of dissolved material, so in the special case of impounded streams the relative size of the reservoir and the annual discharge will be an important factor regulating changes in chemical conditions.

*Paper presented at the 47th ANZAAS Congress, Hobart, 1976.

A further aspect of impoundments is that they may result in quite still conditions prevailing where otherwise they would not. This may be of special importance in the Australian situation where turbid waters are very common.

The aim of this paper is to present some results and ideas which identify the factors which define the chemical environment of impoundments.

Results and Discussion

1. The effect of discharge on concentration of dissolved material

An empirical relationship between stream discharge, Q and ionic concentration C at a given point in a stream is:

$$C = aQ^b$$

or $\log C = \log a + b \log Q$ where a and b are constants (Hem 1970). Hall (1970, 1971) has provided a theoretical derivation for this equation and for some others which may apply.

Equations of this sort can be applied to the data for a wide variety of flowing waters over much of their annual cycles. Some results for the Derwent R. in Tasmania and for some English streams (Edwards 1973) are summarised in Table 1.

Tables like Table 1 are a convenient means of summarising chemical data for flowing water. Table 1 shows that the various ions may concentrate or dilute with increasing discharge, the particular behaviour depending on the catchment concerned; it also indicates that the questions can be applied with some confidence; in most cases the error involved in calculating concentration from discharge in this way is of the same order as the analytical error.

Figure 1 summarises the major ion behaviour for the Derwent R. at a number of discharge values which have been recorded for it. This indicates the sort of range of chemical conditions normally experienced.

For a relatively small impoundment, then, the chemical character is fairly predictable. For large impoundments, the effect of mixing of waters will tend to obliterate the relationship.

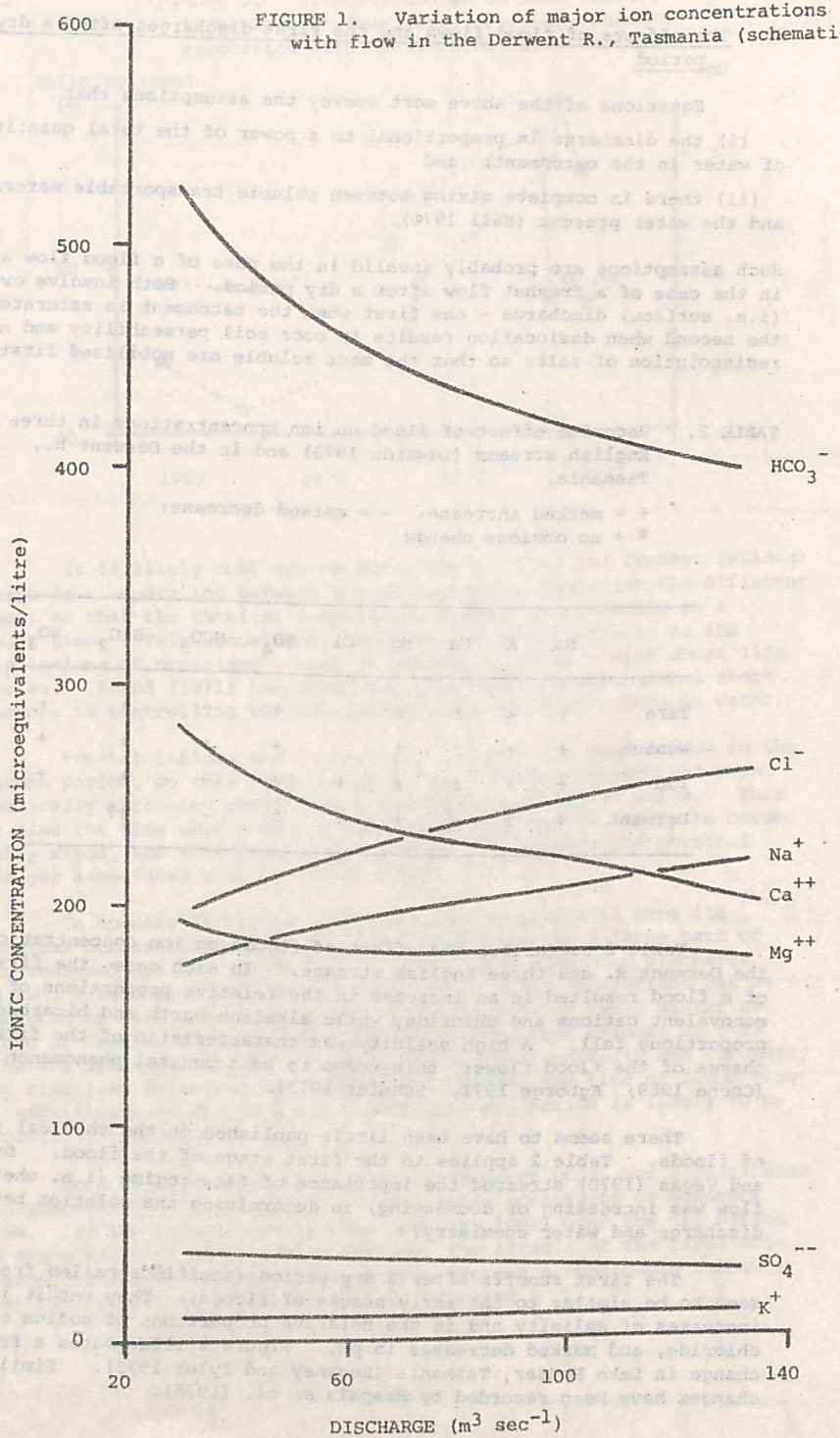
Conditions as defined by these equations may apply for a very large part of the annual cycle for a permanent stream.

TABLE 1. Values of the coefficient (a) and exponent (b) for the relation between concentration, c, and discharge, Q, ($c = aQ^b$) for some English streams (Edwards 1973) and for the Derwent R., Tasmania. r is the correlation coefficient, * indicates significance at 95% level or better.

	Na^+			K^+			Ca^{2+}			Mg^{2+}		
	a	b	r^2	a	b	r^2	a	b	r^2	a	b	r^2
R. Yare	37	-.10	0.66*			0.25			0.22	5.9	-.07	0.77*
R. Wensum	35	-.03	.36*	3.1	.16	.36*	120	.05	.36*	4.8	-.06	.58*
R. Tud	31	.06	.38*	4.3	.15	.55*	141	.07	.43*	4.0	-.13	.66*
Derwent R.	115	.13	0.73*	9.6	.01	0.16	547	-.20	0.71*	242	-.07	0.47

	Cl^-			SO_4^{2-}			HCO_3^-			SiO_2			NO_3^--N			PO_4^{3-}-P		
	a	b	r^2	a	b	r^2	a	b	r^2	a	b	r^2	a	b	r^2	a	b	r^2
R. Yare			0.11	26	.21	0.75*	333	-.05	0.53*			0.05	4.5	0.41	0.77*	0.2	-0.59	0.67*
R. Wensum			0.0	11	.31	.71*	309	-.06	.55*			.22	2.6	0.52	0.84*	0.2	0.41	0.44*
R. Tud	45	.08	.41*	30	.22	.64*			.23			.05	9.2	0.41	0.89*			0.03
Derwent R.	123	.15	0.69*	58	-.11	0.53	949	-.18	0.68*	1.4	.42	0.60*						

FIGURE 1. Variation of major ion concentrations with flow in the Derwent R., Tasmania (schematic).



2. The effects of flood flows and the first discharges after a dry period

Equations of the above sort convey the assumptions that

(i) the discharge is proportional to a power of the total quantity of water in the catchment; and

(ii) there is complete mixing between soluble transportable material and the water present (Hall 1970).

Such assumptions are probably invalid in the case of a flood flow and in the case of a freshet flow after a dry period. Both involve overland (i.e. surface) discharge - the first when the catchment is saturated and the second when desiccation results in poor soil permeability and slow redissolution of salts so that the most soluble are mobilised first.

TABLE 2. Recorded effect of flood on ion concentrations in three English streams (Edwards 1973) and in the Derwent R., Tasmania.

\+ = marked increase: - = marked decrease:
± + no obvious change

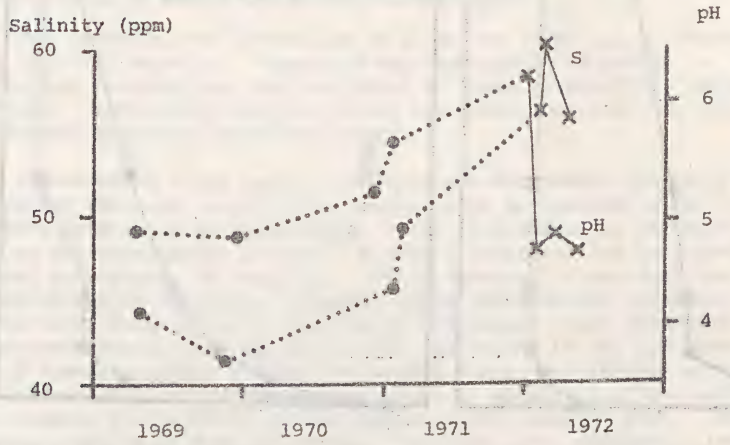
	Na	K	Ca	Mg	Cl	SO_4	NCO_3	SiO_2	NO_3
Yare	+	+	±	±		+	-	+	+
Wensum	+	+	±	±		+	-	+	+
Tud	+	+	±	±	+	+	-	+	+
Derwent	+	±	-	+	+	±	-	+?	

Table 2 summarises the effect of floods on ion concentrations in the Derwent R. and three English streams. In each case, the first stage of a flood resulted in an increase in the relative proportions of the monovalent cations and chloride, while alkaline earth and bicarbonate proportions fell. A high salinity was characteristic of the first phases of the flood flows; this seems to be a general phenomenon (Coche 1969; Egborge 1971; Schmidt 1972).

There seems to have been little published on the chemical nature of floods. Table 2 applies to the first stage of the flood. Dvihally and Vagas (1970) stressed the importance of flow regime (i.e. whether flow was increasing or decreasing) in determining the relation between discharge and water chemistry.

The first runoffs after a dry period (sometimes called freshets) seem to be similar to the early stages of floods. They result in increases of salinity and in the relative proportions of sodium and chloride, and marked decreases in pH. Figure 2 illustrates a freshet change in Lake Pedder, Tasmania (Buckney and Tyler 1973). Similar changes have been recorded by Haapala *et al.* (1975).

FIGURE 2. Salinity and pH in Lake Pedder, Tasmania over four years. ✕——✕ : changes associated with heavy rains early in 1972.



It is likely that during these times (flood and freshet inflows) there is a separation between the concentration peaks for the different ions, so that the chemical composition changes dramatically in a short time. This conceivably could have dramatic effects on the populations of organisms - such as planktonic algae - with short life cycles. Round (1971) has discussed the idea of environmental shock factors in controlling the development of algal populations in water.

Freshet inflows and - sometimes - floods are most common in the Autumn period, so this time may be one of rapidly changing and even chemically stressing conditions for simple organisms in lakes. This is also the time when a deep stratifying reservoir is likely to become fully mixed, and this process has particular chemical and physical changes associated with it (Round 1971).

In summary it can be said that a water body will have its chemical conditions defined by the discharge during a large part of its seasonal cycle. Salinity will tend to be high when discharge is low. Salinity, pH, nutrient and major ion concentrations can be expected to fluctuate very rapidly in the autumn or early winter as flood or freshet flows become important. Physical changes at this time are also pronounced. Temperature may fall markedly and turbidity may rise (see Tyler and Buckney 1974). Hence, the time of flood flow or significant discharge after a prolonged dry period is likely to be ecologically critical.

Such changes can be expected in any water body, but a particular management regime for a reservoir may either accentuate or moderate them. If the practice is to draw down the level over the dry period in expectation of large winter inflows, the effects of the first wet-season runoffs are likely to be marked, whereas a comparable reservoir kept nearly full is likely to be less affected.

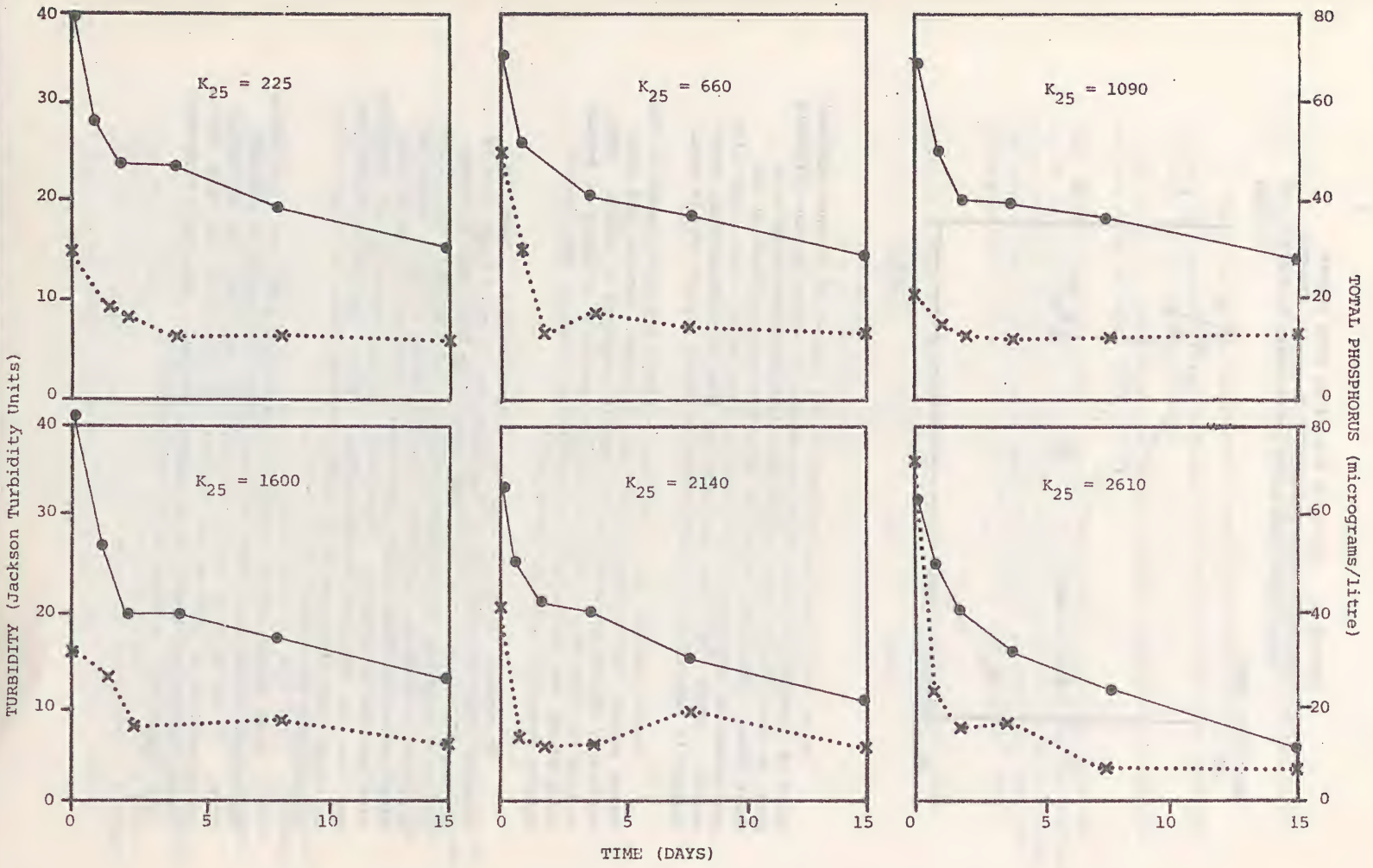


FIGURE 3. Changes in turbidity (●——●) and total phosphorus concentration (✱···✱) for some waters allowed to stand in the laboratory. Conductivities at 25°C (K_{25}) measured in μScm^{-1}.

3. The effect of still conditions on turbidity

The potential for production in a flowing river may be depressed by two physical factors. These are the restriction of growth in fast-flowing sections and the limitation of light intensity by suspended particles. Such waters may have total nutrient concentrations which would otherwise permit extensive growth.

Impoundments often produce conditions which permit the settling of suspended material, and in this better light environment algal and macrophyte production is encouraged. This is probably an important factor in the development of the late-spring profileration of attached algae and macrophytes in farm dams. For planktonic organisms, the same phenomenon is expected; however, since these obtain nutrients from the water column - free of littoral influences - the sedimentation of suspended material may cause nutrient limitation in the open water. Figure 3 summarises some results for waters which were allowed to stand in the laboratory. A pronounced reduction in turbidity of the surface layer occurred in the first day and proceeded for several days. This change was associated with significant falls in total phosphorus levels.

During this experiment, the sedimentation flux of phosphorus was as high as 1 $g.m^{-2}yr^{-1}$, and is comparable to the critical loading figures for a eutrophic lake (Vollenweider 1968). While such perfectly still conditions rarely prevail in nature, effects such as this could be a significant component of the nutrient budget in the short term.

The changes were greatest in the more saline waters, which suggests that the summer period (characterized by increasing salinity) is the time when turbidity reduction will be greatest.

The above suggests that where nutrient levels are high, consideration should be given to selecting dam-sites which afford good exposure to prevailing winds which will prevent the prolonged maintenance of still conditions, and the development of higher light intensities in the water column.

Conclusion

It is clear that water movement exerts an over-riding control on the chemical events which occur in most inland waters. In some cases, chemical changes (changes in nutrient concentrations, for example) may have important biological effects. There is a good case for more critical examination of the importance of water movement in such waters.

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TROPICAL MAN-MADE LAKES - THEIR ECOLOGICAL IMPACT*

By T. Petr

(Zoology Department, Monash University)

Historical background

While many of the temperate region rivers have been harnessed to their capacity by dams to produce electricity, provide water supply and to serve other purposes, until recently the tropical and subtropical rivers have been spared any drastic human influence. It is estimated that at present approximately 10% of the world's total annual stream flow is regulated by man. At the time of its construction, the Kariba dam (closed in 1958) - the first project of this magnitude in underdeveloped tropical countries - was the largest single civil engineering project ever undertaken in Africa and produced what was then the largest man-made lake in the world (Webster 1975). Since that time techniques have made it possible to proceed much faster and on a much greater scale with building dams. It is estimated that by the year 2000 two thirds of the total stream flow will be regulated (Szesztay 1972). The majority of future projects can be expected to take place in the developing countries of the topics and subtropics.

The first large tropical man-made lakes which flooded an area larger than 1000 km^2 appeared on the maps in the late 50's and in the 60's. The majority of these dams were constructed in Africa, but one large project appeared in South America in Surinam (Table 1). With the exception of the Aswan Dam, their primary purpose was to generate hydroelectric power. Only the Aswan Dam was proposed as a multidisciplinary project, both for production of the hydropower, as well as for irrigation purposes.

Environmental science associated with the development of large tropical impoundments has developed only gradually. One has to remember that public attention was drawn to the importance of the environment in the tropical world only relatively recently. The building of first large dams such as Kariba on the Zambesi, Akosombo on the Volta, Brokopondo on the Surinam was accompanied by the establishment of small research units usually associated with universities, or governmental organizations, and largely manned by expatriates. These units started work usually when the construction was in full progress. Thus for these three projects we have poor information concerning the situation that existed before damming the river.

Papers presented at the first two conferences on man-made lakes in London (1965), and in Accra (1966) (Lowe-McConnell 1966; Obeng 1969) provided most valuable data on the first stage of filling the MML, but they still had rather limited predictive potential.

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*Paper presented at the 47th ANZAAS Congress, Hobart, 1976.

TABLE 1. The major man-made lakes in the tropical belt

Lake	Size of the full lake (Km^{-2})	Dam formed on the river (country)	Geographic or vegetation zone
Africa			
Volta	8482	Volta (Ghana)	savanna-woodland
Kariba	5250	Zambezi (Zambia, Rhodesia)	savanna-woodland
Cabora Bassa	2739	Zambezi (Mozambique)	savanna
Nasser/Nubia	3330	Nile (Egypt)	desert
Kainji	1270	Niger (Nigeria)	savanna
Kossou	1600	White Bandama (Ivory Coast)	forest-savanna
South America			
Brokopondo	1560	Surinam (Surinam)	forest
Australia			
Argyle	2050	Ord (Australia)	savanna

Dam closed	Period of filling (yrs)	Max. depth (m^{-1})	Max. drawdown (m^{-1})	Ratio of annual outflow to volume
May 1964	5	75	4	1:4
Dec. 1958	4½	120	14	1:9
Dec. 1974	1	151	36	-
1964	10	130	10	1:2
Aug. 1968	3 months	50	11	4:1
Feb. 1971	7(?)	54	3	1:5
1967	7	46	3	-
Nov. 1971	<1(*)	68(**)	-	-

* filled to tunnel intake level within the first wet season

** dam height above original river level

Note: the data as presented in this table may differ from those of other authors. This table is based on the most recent information available.

The environmental research of large man-made lakes was greatly boosted by the later involvement of international, especially U.N., organizations which eventually took over the coordination of research on the African Man-made lakes, i.e. the studies became an international responsibility. As the collection of scientific and socio-economic data accelerated, native residents have become more and more involved in the research work as well.

The analytical approach has become apparent at the third conference on man-made lakes held in 1971 in Knoxville (Ackermann *et al.* 1973). But in spite of the greatly increased effort in gathering information it has been recognized that the most comprehensive efforts in many parts of the world have been salvage operations. This has resulted in an uneveness in treatment, and a fragmentation of information thus preventing a holistic picture of the total impact of a reservoir in a general geographic context (Ackermann *et al.* 1973). This resulted initially in largely speculative management, which has been gradually changing to systems which introduce corrective measures on the basis of firm scientific and socio-economic knowledge. Thus, rationalisation is replacing adventurism (Allsopp 1974).

The first comprehensive summation of knowledge of tropical man-made lakes was presented in the Scope report (1972), and this report was also used, with only minor modification, as a Summary of Symposium and Recommendations for the Knoxville Symposium.

The new knowledge has been used for formation of guidelines for policy and planning which are based on an analysis of the environmental impact of large tropical man-made lakes (Freeman 1974; Dasmann *et al.* 1974).

Process of ecological changes in tropical man-made lakes

Freeman (1974) produced a simplified graphic treatment of the various consequences of impoundment of a tropic river based largely on the case study of the Volta Lake in Ghana. Balon (1974) provided a graphical representation of the physico-chemical and biological changes, based on experience from Lake Kariba. This, with slight modifications, can be applied to a number of existing and future tropical man-made lakes.

The lessons learned from the existing dams and their impoundments, have shown a number of environmental changes in common to many, if not all large new tropical man-made lakes. In agreement with man-made lakes outside the tropics, the initially high productivity of a tropical impoundment is followed by a decline in its productivity corresponding to a change from eutrophy to oligotrophy. A fish population explosion leads to an intensive fishing activity during the first years after flooding and this is followed by decline in catches. During the relatively high nutrient content in the water, noxious aquatic weeds such as *Salvinia molesta, Eichhornia crassipes, Pistia stratiotes* may appear in large quantities, blocking off the water layer beneath them, and producing poor oxygen concentration. Mechanically, the weeds interfere with transport, fishing and generation of electricity. The weeds may harbour snails and/or mosquito larvae, and these may function as vectors of parasitic diseases such as schistosomiasis, filariasis and malaria. On the positive side the flooding of rapids - the sites of black-fly larvae - leads to a disappearance of the vector pool of

the river blindness parasite *Onchocerca*.

In the Brokopondo scheme situated in a thinly populated tropical rain forest, the direct dam-induced ecological disturbances affecting human health were minimal: the acid oligotrophic character of water was unsuitable for *Schistosoma* snail vectors, and the water plants such as water hyacinth were inhabited only by non-biting midge larvae (Leentvaar 1975). This prevented an explosion of parasitic diseases known from African lakes. The only health problem at Brokopondo was presented by the discharge of hydrogen sulfide rich waters from the lake, which even 10 years after the closing of the dam prevented the Bush Negroes from taking the river water for drinking and washing.

The stabilised stage of a man-made lake is considered to be reached when fluctuations in its biological parameters of production exceed only lightly, if at all, those in natural lakes of similar physical characteristics and like latitude and elevation (Ackermann *et al.* 1973).

In developing African countries, the health problems have been tackled with varying success by local health organizations, supported by WHO, which organization also became involved in the attempts of removal of noxious weeds. The fisheries management problems have been guided by FAO and this organization also became involved in the studies of socio-economic character.

Present opinion on stabilization of some tropical man-made lakes has been based only on some environmental factors rather than on the whole ecosystem. Although the rate of change is considerably slower in lakes 8+ years old, changes still take place. This is documented for example by shifts in dominant fish species both in Lake Kariba (Balon 1974) and in Lake Volta.

The downstream effect of tropical man-made lakes

There is a great paucity in our knowledge on the downstream effects of large tropical man-made lakes. The regulation of the Lower Volta in Ghana by the Akosombo Dam effectively stopped lateral migrations of fish during floods. Also, it resulted in a higher upstream salt-water penetration along the river bed and this reduced the areas suitable for spawning of the river clam *Egeria* (Pople and Rogoyska 1969). The aquatic weeds became much more common and while supporting large populations of snails, this resulted in an increase in schistosomiasis among the villagers (Kpong 1975).

The Kainji Dam is known to influence fish migrations in the Niger below the dam which in turn has resulted in a decrease in fish landings (Lelek 1973). The effects of the Aswan Dam have been extensively discussed in a number of papers (e.g. Worthington 1973, Jackson 1975) and can be summarised as: the reduction in nutrient load and solids in the Nile below the dam, and in its consequences on Egyptian agriculture and water fertility, the latter especially affecting the adjacent Mediterranean, resulting there in a drastic decline in populations of sardines. The increased erosion of the Nile delta is becoming more and more obvious (Kassas 1973). The Kariba, to a large extent regulating the dry and flood flow in the Zambezi, affected fish migrations. Before the appearance of a large dam below Kariba, the Cabora Bassa, the migrating eels were able to

overcome the Kariba Dam (Balon 1974). It appears that this has been definitely eliminated by the Cabora Bassa (Davies *et al.* 1975). Similarly as other tropical man-made lakes, Cabora Bassa will function as a silt trap, probably leading to an increased erosion of the estuary and the delta of the Zambezi. The regulation of the Zambezi by Kariba Dam led to a change of vegetation on flood plains resulting in a drier vegetation type and a failure to allow the vegetation to recover naturally from the effect of grazing by game (Attwell 1970). The same is expected to happen below the Cabora Bassa threatening especially the rich wildlife in the delta (Davies *et al.* 1975).

The southeast Asian tropical Australian estuaries are well-known for their prawn concentrations, especially from the family Penaeidae. Also the freshwater giant prawn *Macrobrachium rosenbergii* is widely distributed in both freshwater and brackish waters, and form a base for an industry. All prawns are eaten by fish thus occupying an important link in the estuarine food chain. It is not known how the Ord Scheme has affected the concentrations of prawns in the river mouth and the adjacent sea, but a pilot scheme of culturing *Macrobrachium* in aquaculture using the Ord River water in special ponds in planned at Kununurra (Aust. Fisheries 1975, Sept.). The young prawns will be flown there from South Australia, to grow to market size. If there were an ample supply of prawns in the Ord River mouth this project would probably not be considered economically viable.

In the Purari River in Papua New Guinea trapping of sediments in the proposed dam is considered a possible hazard for the delta biota as it might result in a partial loss of the nutritive value of the delta sediments on which some prawns may feed. This could affect the fish population of the delta as the majority of fish feed on prawns (Petr 1975). The loss of sediments will obviously be greater if a series of dams on the same river system is built.

In connection with the downstream effects on the ecosystem, one should not overlook the consequences of building a dam on a tropical river situated in an arid region which ends in a terrestrial lake without an outflow. Such lakes exist in the tropics, e.g. Lake Chad in Africa. The drastic changes in the environment of the Caspian Sea due to the reduced flow from the Volga after building a cascade of dams is well known (Micklin 1974). Less known is the recent case of Lake Balkhash where aquatic life is threatened by the increasing salinity as a result of damming the Ili River, the major inflow of this lake (Sechnoy 1975). Lake Chad which has been recently in a drying out phase, would certainly be greatly endangered by damming the Chari River, its major inflow.

Criticism of large projects

The increasing public awareness of the importance of tropical environments has increased the criticism of large projects in developing countries. As more and more data on unforeseen adverse consequences of large dam constructions have been accumulated, the people concerned want better protection from them.

The criticism of large projects in developing countries seems to be largely justified. The Aswan Dam's adverse impact on fertility of the downstream Nile, the great spread of bilharzia among human populations on the Volta, and the disturbance of traditional social contacts figure among the major points of the criticism.

Comprehensive, long-term evaluations of the social and economical aspects of past river basin development projects are desirable, as well as long-term environmental research and monitoring in river basins likely to undergo development (Dasmann *et al.* 1974). Environmentalists call for multi-purpose reservoirs which would offer a wide range of benefits. This is substantiated by the failure to anticipate and evaluate adequately the various adverse and ecological consequences that were not anticipated by planners. A number of such cases was presented at the conference on the ecological aspects of international development in Warrenton in 1968 (Farvar and Milton 1973) and invariably careless technology was blamed for them. It appears that not only the careless technology but also the lack of clear management strategies confront the success of tropical man-made lakes. The complexity of the environment and circumstances makes management often impossible. The turning to systems of speculative management resulted as developments were outpacing the availability of scientifically adequate data translatable into management measures. This became evident especially in fisheries development (Allsopp 1974).

The criticism of large tropical man-made lakes for their environmental impact is based also on the fact that the engineering aspects of large hydroelectric schemes are much easier to predict than the environmental ones. This is becoming more and more evident as more information becomes available. Also, it was soon ascertained that the likely course of physical, chemical and some biological events in tropical man-made lakes is more predictable than sociocultural events. The difficulties that arise are usually due to lack of attention to secondary problems and costs that have often undermined the effectiveness of the original development objectives. It has become more and more obvious that the case for constructing a reservoir is often stressed at the expense of possible alternative development patterns that take better account of the ecological and social factors (Dasmann *et al.* 1974). The Summary and Recommendations from the Third Man-made Lake's Conference (Ackermann *et al.* 1973) indicated that the people and their sociocultural system must, to a considerable extent, be considered a man-made ecosystem as the environmental changes may provoke a crisis of individual and cultural identity. Solving secondary problems which appear as a result of the formation of an impoundment in a tropical country, is not cheap. The cost of UNDP programmes carried out in four major African dam projects (Volta, Kainji, Kariba, Nasser/Nubia) was estimated in 1974 to be $US8.8 million (Freeman 1974). This includes research and training in fisheries, limnology, hydrology, epidemiology and agriculture.

The present clash appears to be not as much as between engineers and environmentalists as between politicians and economists on one side, and environmentalists. The environmentalist requires money and time, while the politician wants an immediate effect. Developing countries feel that industrialization is the only way to increase rapidly their living standard. The cheap, and environmentally clean source of energy is hydropower. As Freeman (1974) pointed out, such a large scale project gathers its own political and institutional momentum and becomes an increasingly more substantial commitment by governments. To the extent that these conditions create complexity in design, environmental impact studies should be initiated as early as possible.

Another important point is that a sound environmental study is expensive, and some countries simply cannot afford such a study without external help. Environmentalists hesitate to base their decision on inadequate knowledge, but an adequate knowledge can be based only on long-term observations. At the level of pre-investment studies, i.e. prior to impoundment, long-term (more than 1 year) observations of many environmental parameters are necessary if an adequate impact assessment is to be provided. In case of the Purari hydroelectric power scheme in Papua New Guinea, in the proposal for environmental studies the cost is estimated at $US2.3 million (Goldman *et al.* 1975). It becomes obvious that without an international assistance a country such as Papua New Guinea will not be able to undertake such a study. Reduction of cost is possible only by careful organization and management of internal scientific and technical man-power, and this will much depend on the manager of such a project.

It is also true that many scientists still believe that a decision can be based only on absolute, or near absolute knowledge. That this attitude is not always in the interest of environment is well-known from the fisheries where the absolute proof of decline in fish stock is its total disappearance. Too often conservation measures have been delayed and great damage done to the stock and the fishery on it by the demand for complete and conclusive biological evidence; the final conclusive proof that a stock is being depleted is when it becomes extinct (Gulland and Carroz 1968).

Among other problems faced by developing countries is their political and economic instability. There are few projects in the tropics where progress on large projects would not have been slowed down by internal turmoil. The environmental research on the Cabora Bassa was made extremely difficult before and during the filling stage of this lake resulting in loss of valuable and irreplaceable information. The future of the Mekong River Scheme appears to be unknown. In Australia, the lack of research on the Ord Scheme indicated that even in well advanced and industrialized countries research opportunities can be wasted.

Tropical man-made lake - the Ord Scheme

The Argyle Lake (Ord Dam) in Western Australia is the first large tropical man-made lake in Australia. At present, the major difference between this lake and those mentioned above is that it serves irrigation only.

The first stage of the Ord Scheme completed in 1963 consisted of construction of the Kununurra Diversion Dam, and resulted in the irrigation of hundreds of acres of land. During the second stage, some 100 miles south-east of Wyndham, the Ord River Dam was built and a major storage, Lake Argyle, was formed (the dam was closed in 1972). In the third stage it is anticipated that a 30,000 kw hydroelectric power station will be constructed. Thus, the principal function of the Ord River Dam is to hold a vast quantity of water in reserve and release it in a controlled manner to keep the diversion dam full. The considerable difference between the area of water surface at the maximum flood (800 square miles) and that at the normal full supply level (286 square miles) makes this lake one with the highest range of water level fluctuation among tropical man-made lakes.

Among the large tropical man-made lakes, the uniqueness of the Ord Scheme is its complete dependence for water supply on a stream which may cease to flow for part of the year. It is situated in a southern tropical monsoonal climate. The erratic nature of the Ord can be illustrated by a flow which within 3 weeks changed from 20,000 cubic feet per second to 3,000 cubic feet per second.

Since the inception of the plan, the Ord Scheme has been heavily criticised. Recently, in connection with the proposal of establishing sugar industry in the area it was called a nation's outstanding monument to political expedience (The Age, April 2, 1976). From the same source it was stated that Lake Argyle is a "wildlife heaven and the world's most costly duckpond". The life in the area was characterized by Stanley (1975) as "fight against heat, humidity, high freight costs, insects and microbes". He also stated that "numerous problems that Australian scientists have not yet examined although studies should have commenced well before the dam was constructed". Today, the Ord Scheme can be considered as another example of a missed opportunity for solid scientific environmental reserach before a decision was made.

A number of tropical and subtropical dam projects has been heavily criticised for lack of sound environmental studies prior to the decision, or prior to the construction of a dam. The remoteness of their sites makes environmental studies on them much more costly than of those projects constructed in industrialized countries or regions. Research is in a certain respect a luxury, and many countries simply cannot afford it at least not on a scale on which one would like to see. Even Australia decided to spend little on hydrobiological research on Lake Argyle and research work started only with the closure of the Kununurra Dam. Apart from data on soils and geology of the area, little data for other aspects such as physics and chemistry of water and the aquatic biota appear to be available at present (Millington 1975). There has been no consistency in collection of scientific data, and today the Ord Scheme environmental studies appear to be far inferior to those which have been carried out on African tropical lakes. The idea of an integrated activity of many people and institutions in research was slowly recognized by both science and government only after Lake Argyle filled (Stanley 1975). It was suggested that apart from involving State and Federal governments, international collaboration should be invited. But so far, no action has been taken to improve the situation.

Williams (1973) expressed scepticism about the suitability of much overseas research for Australian conditions. Just because of that the Ord Scheme should have served as a pioneering study for Australian conditions. The uniqueness of the Ord Scheme may perhaps be in the paucity of the original aquatic biota in the periodical stream, and not so much in the water chemistry. Lake Argyle water has for Australian conditions a low ionic content, with conductivity (K 20^{o}) of 170µS and it is a bicarbonate type of water of low salinity (Millington 1975). Thus chemically it is reasonably close to a large man-made African lake. It certainly differs from them in its paucity of aquatic life, especially the indigenous fish and perhaps some other aquatic organisms. However, if required, species inhabiting permanent rivers of the northern Australian area could be introduced.

Millington (1975) when discussing the agricultural implications of the Ord River Dam recognized that "the evolution of an ecosystem acceptable to man may prove more difficult than satisfying the needs of his crop plants and domestic animals". His review included also social aspects of life in the Ord Valley which indicated that the problems are similar to those in developing countries, but that they are on a higher level (poor quality of housing, lack of air-conditioners, lack of contacts, little sense of belonging to the place), and that these contribute to the sociological instability of the region. Thus, in a developed country such as Australia, a rapid amelioration of the social and economic problems appears to be a matter of priority, to be considered in parallel with the monitoring and decision making on the engineering, agricultural and hydrobiological ecosystem aspects.

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(N.B. See Postscript, page 38)

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THE CONCEPT OF EUTROPHICATION*

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Abstract

Since introduction of the term "eutrophic" in 1907 the adjective and its adjectival noun "eutrophication" have developed meanings and usage which are far from consistent albeit more subtle and extensive. Usage in the literature defines eutrophication in a variety of ways. This essay considers the variety of definitions and meanings leading to a holistic or ecosystem scheme of reference in which eutrophication is defined. The Laurentian Great Lakes are seen as atypical of the model arising from this definition.

The role of nutrients in eutrophication is discussed indicating that the limiting nutrient idea may not be fruitfully employed. Further examination of eutrophication indicates complexity in terms of dynamics and participation of elements not suspected as participants in the system's chemical dynamics.

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Ed.

THE CONCEPT OF EUTROPHICATION

Introduction

The term 'eutrophic' has a history of nearly 70 years of usage in the scientific literature, having been introduced by Weber in 1907 to describe the general nutrient conditions in German bogs. The concept of eutrophication, while retaining the important nutritional meaning of 'eutrophic' has developed broader or richer significance as knowledge has grown. A review of the literature reveals however that usage of the term, even in expert circles, does not imply that more significant meaning. It is one of the purposes of this essay, therefore, to explore the concept of eutrophication in order to present a satisfactory, satisfying meaning for the term, adequate for present day usage and knowledge. This would appear to be necessary in that eutrophication constitutes "one of the most pressing of contemporary problems" (Schindler 1974), especially in North America and Western Europe. Here eutrophication of freshwater bodies can be indisputably linked with man's inefficiency in disposing of nutrient-rich wastes. These wastes are products of urbanization, industrialization and agriculture, all on extensive and intensive scales.

Such activities are usually blamed as the immediate fundamental source of the phenomenon of such eutrophication, but Vallentyne (1972) finds the ultimate cause in the mid-nineteenth century decision to adopt water transport as a means of disposal of human waste. This decision arose from the discovery that the disease cholera was transmitted through drinking water. Vallentyne shows how with the implementation of this decision the ecologically beneficial nutrient cycle man-soil-plant-food-man changed, leading to a unidirectional and wasteful flow of nutrients shown by the sequence fertilizer-soil-plant-food-man-sewage-river-sea. Lakes and impoundments, in causing a delay in the flow of streams to the sea, provide major opportunities for the processes of eutrophication to occur, together with their manifestations.

Towards a comprehensive concept of eutrophication

Eutrophication has been variously described or defined in terms of its causes, consequences or its processes (a distinction has also been drawn between natural and cultural (man-caused) eutrophication). Thus Schindler (1974) defines the term as "the rapid increase in algae and other aquatic weeds in natural waters"; Bayly and Williams (1973) use the term "eutrophic" synonymously with "nutrient-rich" (page 64) and (cultural) eutrophication as an unnatural acceleration in the nature of a lake from oligotrophic (nutrient-poor) to eutrophic condition (page 256). The definition adopted by the Organization for Economic Cooperation and Development (OECD) is broader and more descriptive. It is quoted by Bartsch (1972) as follows:

"Eutrophication is the nutrient enrichment of waters which results in stimulation of an array of symptomatic changes among which is increased production of algae and macrophytes, deterioration of fisheries; deterioration of water quality and other symptomatic changes are found to be undesirable and interfere with water uses."

Beeton and Edmondson (1972) have remarked on the tendency for many people to use the term "eutrophic" synonymously with "highly productive". They indicate however that the mechanism of nutrient usage can vary widely in different lakes - the rate of production and the resulting biotal population densities are affected by factors other than the nutrient supply. Such factors include solar radiation, turbidity, wind exposure, shape and size of water body. Secondly the term "highly productive" is less than adequate for a general description of eutrophication in lakes.

Eutrophication has also been viewed (Likens 1972) as a natural aging process in undisturbed lakes, a process which eventually terminates in the disappearance of the lake itself. Vast accelerations of this process by the activities of man have been termed "cultural eutrophication" leading to applied or popular definitions of eutrophication which are man-centred. However Beeton and Edmondson (1972) have pointed out that there is no evidence for a slow steady (natural) increase in nutrient supply throughout the existence of a lake. Sudden natural increases in nutrient input have (on the palaeolimnological evidence) resulted in the attainment of a trophic equilibrium. The activities of man, however, lead to continually accelerating rates of nutrient input, thus precluding the attainment of such an equilibrium and leading to the symptomatic changes described by the OECD statement quoted above. For these reasons Beeton and Edmondson question whether any natural process can usefully be described as "natural eutrophication".

Rodhe (1969) and others have discussed the use of either nutrient concentration or the rate of production of organic matter as criteria for classifying lakes as oligotrophic or eutrophic. Likens (1972) views both criteria as important, since, on the one hand, nutritional enrichment is an important indicator of potential for photosynthesis (usually a dominant consideration) while, on the other hand, some "well-nourished" lake ecosystems are based largely on a high input of allochthonous organic matter. Likens therefore claims that "from an ecosystem viewpoint, we can broadly define eutrophication as nutrient or organic matter enrichment, or both, that results in high biological productivity and a decreased volume within an ecosystem".

It should be noted that, as well as including organic material within its ambit, such a definition takes the whole ecosystem as its reference. This holistic view is supported by that of Hutchinson (1969) who directs attention away from the tendency to use water types as a means of classification. "... we should not think of oligotrophic or eutrophic water types, but of lakes and their drainage basins and sediments as forming oligotrophic or eutrophic systems ... By a eutrophic system I mean one in which the total potential concentration of nutrients is high; there may happen to be an extremely low concentration in the water because the whole supply at that moment is locked up somewhere else in the system - in sediments or in the bodies of organisms."

Likens (1972) has proposed a lake ecosystem model which can be fruitfully used to discuss and summarize the above ideas concerning eutrophication. This model is represented diagrammatically in Figure 1. While space requirements prevent a detailed discussion of this model, it can be seen that man-induced increases in the biologic and geologic inputs to the system may upset the intrasystem equilibria leading to increased biologic and geologic outputs.

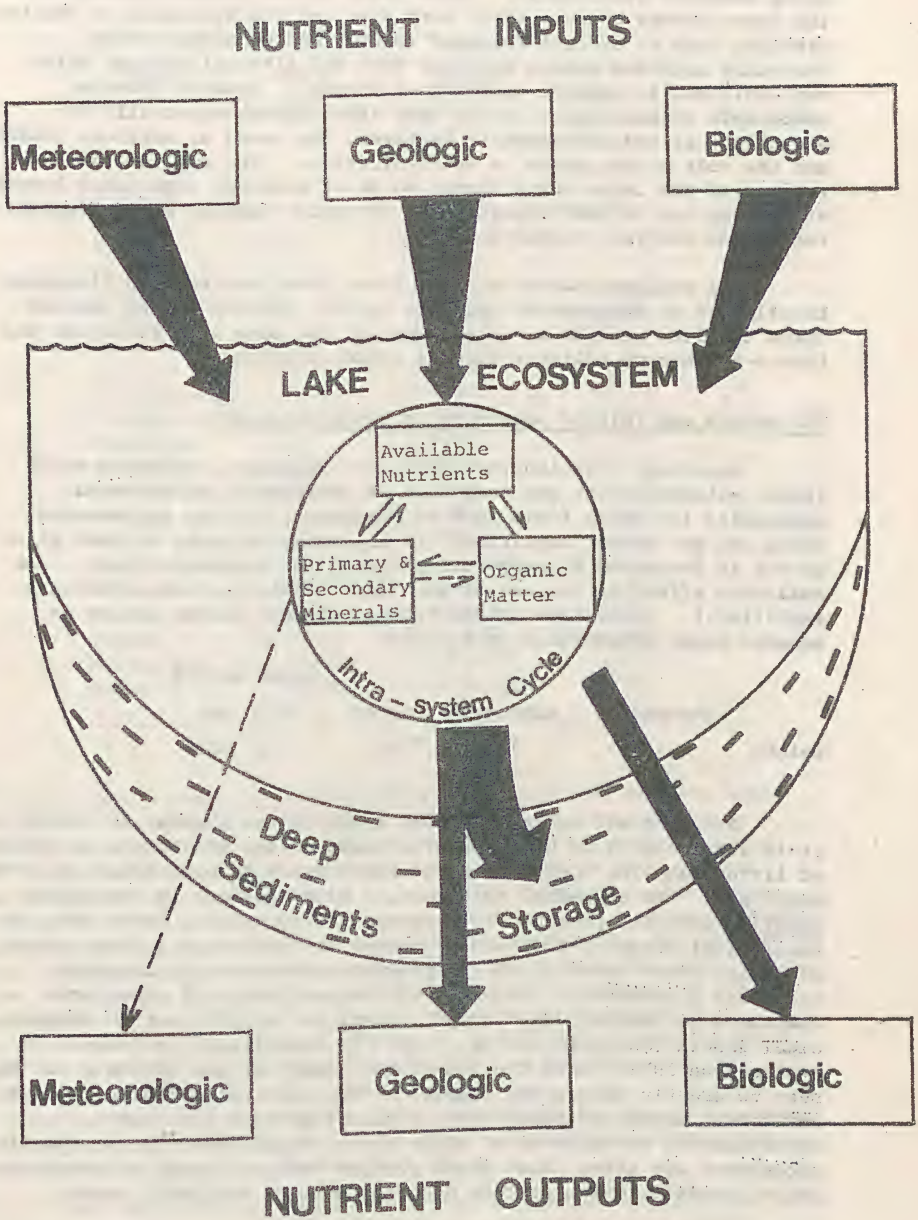

FIGURE 1. Liken's model for nutrient flux in a lake ecosystem.

When applied to very large lakes such as the Laurentian Great Lakes, the Likens model breaks down in that eutrophication takes place somewhat differently. Such lakes do not respond totally to the above manner because their very size and the diversity of habitats preclude such an overall response (Beeton and Edmondson 1972). Initially nutrient inputs are into bays and littoral regions which may individually undergo substantial change. However, whether comparable changes occur in the open lake depends especially on morphological and morphometric features, the level of nutrient loading and the role of the biota in eutrophication. The shallow water regions of the large lakes appear to be of greatest importance however, since they are of most significance for water supply, waste disposal, recreation and fish production.

The atypical nature of very large lakes having been discussed briefly, it is proposed to restrict further remarks to the smaller lakes typified earlier in this essay, at the same time retaining the Likens-Hutchinson holistic view of eutrophication.

The nature and role of nutrients in eutrophication

Accoring to Vallentyne (1973) the principal nutrients which induce eutrophication are compounds of phosphorus and nitrogen, especially inorganic forms such as phosphate, nitrate and ammonia. These act as "growth amplifiers" in aqueous ecosystems in that plant growth is increased disproportionately to the nutrient input. (An analogous effect is the use of the "gain" control of an electronic amplifier.) Vallentyne quotes typical element weight ratios in aquatic plant communities as follows:

				plant weight	
	phosphorus	nitrogen	carbon	dry	wet
weight	1	7	40	100	500

Assuming all other necessary elements are present in excess, it is clear that 1 kg of phosphorus leads to the production of 500 kg of living material whereas 1 kg nitrogen leads to only 500/7 kg living material. (As a general principle, a given element is considered limiting when its presence in a system is, by weight, lower than the theoretical weight proportion necessary to synthesize a fixed weight of living plant material in the presence of excess of all other necessary nutrients.) Normally the concentration of phosphorus compounds in natural (unpolluted) waters is insufficient to support algal growth (Schindler 1974). This is illustrated in Table 1 (Vallentyne 1972) where the demand for phosphous and nitrogen can be seen to greatly exceed the supply. When such water bodies receive additional inputs of phosphorus, algal production flourishes. Unfortunately the species of algae which respond best to the additional phosphorus are often those which produce noxious tastes or odours in water, secrete toxins or form decaying mats or unsightly scums.

Table 1. Concentration of essential elements for plant growth[a]

Element	Demand plants, %	Supply water, %	Demand/ supply, plant/ water, approx.
Oxygen	80.5	89	1
Hydrogen	9.7	11	1
Carbon[b]	6.5	0.0012	5,000
Silicon[c]	1.3	0.00065	2,000
Nitrogen[b]	0.7	0.000023	30,000
Calcium	0.4	0.0015	<1,000
Potassium	0.3	0.00023	1,300
Phosphorus[b]	0.08	0.000001	80,000
Magnesium	0.07	0.0004	<1,000
Sulfur	0.06	0.0004	<1,000
Chlorine	0.06	0.0008	<1,000
Sodium	0.04	0.0006	<1,000
Iron[d]	0.02	0.00007	<1,000
Manganese	0.0007	0.0000015	<1,000
Boron	0.001	0.00001	<1,000
Zinc	0.0003	0.000001	<1,000
Copper	0.0001	0.000001	<1,000
Molybdenum	0.00005	0.0000003	<1,000
Cobalt	0.000002	0.000000005	<1,000

[a]In the living tissues of freshwater plants (demand), in mean world river water (supply) and the plant/water ratio of concentrations (demand/supply). The concentrations listed for freshwater plants were derived from approximately 20 scientific papers dealing with the chemical composition of algae and rooted aquatic plants. These averages were weighted for annual production ratios of about 7 units of algae to 1 of rooted plants, with diatoms comprising 30% of the total algal production. The concentrations of the same elements in water (except for phosphorus) were derived from estimates of the composition of mean world river water given by Livingstone (4). The estimate for phosphorus supply is my intuitive estimate for mean world river water. [b]The concentrations of carbon, nitrogen and phosphorus in water are given for inorganic forms only. [c]Silicon is essential for the growth of diatoms, some flagellates and perhaps some higher plants *(Equisetum)*. It plays no essential role in the growth of other plants so far as is known.

[d]The listed value of the plant/water ratio is deceptively low for iron, since much of the iron in water is not in a form that is readily available to plants. The true value may be up to several hundred times higher in some lakes.

A typical source of "eutrophic" phosphorus and nitrogen is sewage/sullage effluent (in which household detergents make a major contribution to the phosphate concentration). A typical sewage effluent contains 16 g phosphorus and 80 g nitrogen for each 100 g of constituent carbon (Schindler 1974). Both phosphorus and nitrogen are thus greatly in excess of the typical element weight ratios quoted from Vallentyne above, and are therefore in potentially "eutrophic" concentrations (phosphorus and nitrogen are no longer limiting).

Other sources of importance are the run-off from intensive cattle feedlots and from agricultural land which has been intensively fertilized. In well managed watersheds phosphate losses from such lands tend to be reduced since phosphate is bound effectively to soil particles. However erosion by wind or water of bare soils, fallow land or felled forests can lead to the transportation of phosphorus-rich soil particles to water courses.

The limiting element concept must nevertheless be viewed with some scepticism since it has been shown (Einsele 1936 and Hasler and Einsele 1948) that the chemical dynamics within a lake are just as important as the quantities of material present. Rigler (1956, 1964) has been able to show that the turnover time of ionic phosphorus compounds in the epilimnion of a lake in summer can be of the order of one minute. Moreover Deevey (1972) has indicated that in the growth and nutrition of certain species of algae, almost any element lighter than cobalt and any of several heavier, can set some physiological limit to population growth. Corroborating this, Goldman (1972) claims that while there may be a single factor that is most limiting to the growth of algae at a given time, requirements of different enzyme systems within a single cell make simultaneous limitation by more than one element possible. Yet another complication appears to be the modification of the chemical dynamics of the system by elements not obviously involved as limiting factors. This possibility was shown by Ohle (1954) to be the case with sulphur. Clearly the nature and quantity of algal populations in eutrophic systems are variable and complex functions of chemical composition and dynamics, about which few unequivocal generalizations can be made.

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"MAN-MADE LAKES AND HUMAN HEALTH"

BY N.F. STANLEY AND M.P. ALPERS (EDS.)

Published by Academic Press. xvi + 495 pp. (Price unknown, but discount available to A.S.L. members from Harcourt Bruce Jovanovich Group (Aust.) Pty. Ltd., 25-27 Paul Street, North Ryde, N.S.W. 2113.)

REVIEWED BY K.F. WALKER, UNIVERSITY OF ADELAIDE

The editors of this book set out to demonstrate the basis of their concern for the oft-neglected human health problems ensuing from the construction of large impoundments. Inevitably, there is a bias for tropical environments, where the most serious problems occur. The volume contains 31 articles by people experienced in studies of particular health problems, of particular reservoirs, of certain animals and plants, and in related problems of human ecology. These four broad areas of expertise represent the main groupings of subject matter in the book.

Aside from the fact that the editors are from the University of Western Australia (Department of Microbiology), three papers, concerning the Ord River Dam in the Kimberley Region, are of particular interest for Australian readers. These papers contain useful general information but, as the editors note, there have been regrettable delays in implementing detailed ecological studies of the Ord Dam. Some progress may be expected following the establishment of the Ord River Ecology Committee. It seems, however, that limnologists are not making good use of the opportunities for study in this area!

Efforts have been made in preparation of the book to avoid over-technical writing, ensuring a wider readership. The result is an enjoyable, very readable text, although there is distinct variation in the quality of contributions.

The first section (Specific Health Problems) deals with some of the communicable diseases (schistosomiasis, malaria, leptospirosis, filariasis, and arbovirus infections) favoured by construction of impoundments in tropical waters. The second section (Specific Geographic Areas) contains the afore-mentioned papers on the Ord Dam, and discussions of other projects, including Kariba, Volta Lake, and Brokopondo. The third section (Specific Ecological Factors) is a mixed bag. One article on 'nutrient reactions' (Macgregor and Keeney) purports to be a critical review of the subject, but although it may serve as a general introduction it contains little new material to interest limnologists. A more serious criticism, shared by some other papers in this section, is that it does not address itself to man-made lakes in particular. Four articles that do mesh effectively with the remainder of the volume are those on fish (Jackson), mosquitoes (Paterson), molluscs (Burch), and

insect vectors (Springett). The final section of the book (The Human Aspect) deals with subjects such as resettlement and disease control. A lyrical article ('Dams made by men: an engineer's thoughts on attempts to control nature') by Allen-Williams does little to promote the ecological theme of the book. When are we to be rid of the idea that conservation and preservation are one and the same? And, in the construction of dams, must we continue to pay more respect to something that looks 'grand' than something that truly works?

The book would no doubt receive a more thorough-going analysis in the hands of someone experienced in tropical lake limnology, but from the viewpoint of a general reader, the books seems to serve its purpose well. However, there probably is little new information for those interested in the limnology of man-made lakes. In short, a useful collection of general articles, but of marginal interest for specialists.

An effective summary of the book's important message is provided by the editor's introduction:

- dams and man-made lakes may decrease as well as increase human health and prosperity.
- planning should be multidimensional from the beginning and be based, where possible, on specific, local data.
- ecological changes following the construction of the dam should be monitored.
- the contributions of scientists to planning and monitoring should be interdisciplinary.
- engineers, economists, politicians and scientists should co-ordinate their activities at all stages.
- the responsibility for exploiting and conserving man's most important resource, freshwater, is best entrusted to regional development programs which are international in scope.
- finally, that human health must be given explicit consideration at all stages in the planning, construction and use of man-made lakes.

The last point is the crux: health problems too often are an afterthought of planning. In his article, Waddy concludes with the following: "Lord, Lord, we didna ken" moaned the sinners in hell. And the Lord, in his infinite mercy, replied, "Aweel, ye ken the noo".

* * * * *

"LAKE KARIBA, A MAN-MADE TROPICAL ECOSYSTEM IN CENTRAL AFRICA"

EDITED BY E.K. BALON AND A.G. COCHE

Monographiae Biologicae Vol. 24. 1974, XII + 767 pp., 299 tables, 12 colour photographs. Dr. W. Junk b.v., The Hague, Netherlands. Price: Dutch Glds 210.00.

REVIEWED BY T. PETR, MONASH UNIVERSITY

It was in Zambia in May 1968 that I met Andre Coch and Eugene Balon for the first time. They had been working for FAO on the limnology and fish biology and fisheries problems of Lake Kariba, one of the largest artificial lakes in the world. During my brief stay at JFRO Laboratories and the FAO project headquarters in Chilanga near Kusaka I was introduced to the problems of research on this 5364 km^2 lake which was formed in the early sixties on the Zambesi River. In spite of the long distance between the laboratories and the lake, the shortages of various kinds, slowing down the work, and the increasing difficulties of carrying out research on the whole lake (the UDI by Rhodesia led to restriction of research to one half of the lake only), the work continued. When Eugene left Zambia in 1971, during his stopover in Kampala he showed me part of a voluminous manuscript, representing part of the future book.

The book is written in three parts: Part I (by Andre Coche, later project manager of the man-made Lake Kossou in Ivory Coast, and at present Project Leader of an FAO Fish Culture project in Cameron) deals with limnology; (i) the Zambesi catchment above Kariba dam - general physical background; (ii) the rivers and their characteristics; (iii) Lake Kariba physico-chemical characteristics, and (iv) conclusions. This is 247 pages of encyclopaedic information with a deep look especially at optical and thermal properties of water, and the dissolved gases and chemical content of lake waters. A number of topics are briefly mentioned and referred to literature: benthos (see McLachlan, A. & S. papers), aquatic plants (see Mitchell papers), and little effort is spent on giving a deep analysis of their work. The illustrations are of mixed quality. I have found the following depicting the dynamics of physico-chemical characteristics of water to be most attractive: the evolution of the oxygen and hydrogen sulphide conditions between 1960-1966 (Fig. 48), the phases of chemical evolution (Fig. 55), and comparisons with other African water bodies (chemistry, table 89, 90, Fig. 52). A diagram of temperature changes along longitudinal profiles gives an instructive presentation of the impact of the Zambesi River inflow and of the discharge on water stratification. Water current is one of a number of parameters which are responsible for the non-homogeneous character of large man-made lake water masses, and these lakes, due to the large shoreline and number of narrow arms, are therefore considered to consist of a number of basins, each with its own limnological characteristics.

A traditional error is repeated from Hutchinson who defined total solids as total inorganic material dissolved in water. The APHA Standard Methods (1971, p. 287) defines the total solids as including nonfiltrable (i.e. suspended) residue - that is the portion of the total residues

retained by a filter - and filtrable (i.e. dissolved) residue, that portion of the total residue which passes through the filter.

I much appreciated the conclusion chapter which, although brief, touched on the use of the morphoedaphic index for a quick assessment of lake productivity. Those who enjoy good tables will like the summary of general characteristics of the large African reservoirs (pp. 244-245). This one gives a number of parameters usually not covered by tables of this kind. A study of this table meant for me that my revised version of my previously revised version of a revised version of a table of African man-made lakes would require another revision in the proof of my paper.

The second part of the book is edited (and to a large extent also written) by Eugene Balon. It deals with fish production and it is based mainly on the material obtained by poisoning part of the fish population fenced off in a cove of the lake. This segment of fish population was painstakingly collected by a number of divers, and the tens of thousands of fish down to a few mm preserved before they rotted at water temperatures near 30°C. The taxonomic problems were considerable, the number of morphometric features measured overwhelmingly, and the ageing of tropical fish highly challenging. However, the results provided the base for a number of calculations, ultimately leading to estimates of the total production, available production, and yield of major fish taxa for Lake Kariba. The maze of terms used in the fisheries production literature comes to the surface on p. 441, for example, "Yield: the harvestable part of production is designated here as yield. To emphasize once more this is not the definition of 'yield' used by most fish stock statisticians .... though my term 'available yield' is similar in meaning to the terms 'surplus production' or 'equilibrium catch'."

African waters are an important source of the protein for human consumption, and it is no wonder that an increase in fish production is the aim (and dream) of many biologists. The maximum sustained yield estimate is in the vicinity of 40,000 t yr^{-1}, whereas present fishing exploits only 3,000 t. In spite of this underexploitation, consideration was given to fish introductions, and two clupeids (*Limnothrissa miodon* and *Stolothrissa tanganyicae*) were introduced from Lake Tanganyika. This was done in two airlifts in 1967 and 1968. One of them, *L. miodon*, established itself rapidly in the lake. However, *Alestes lateralis*, a native of the Upper Zambezi, largely absent from the lake in the first years, started colonizing the open water of the lake at about the same time the clupeids were thrown in. The moral of the story appears to be: it is never too late not to introduce exotic fish into the reservoirs.

Balon mentions the ability of eel elvers to climb up the 140 m spillway wall from the river below the dam, and repopulate the lake, where the eels are found now between 25 and 40 m depth.

At present Lake Kariba could provide a potential catch of 43 kg ha^{-1} yr^{-1} (for the areas less than 30 m deep), which is a reasonable fish harvest. In spite of that, Lake Kariba is considered to be oligotrophic and of low productivity. The limnological processes and the production changes in the lake are summarized in an excellent diagram (Fig. 99) with predictive value. In this diagram the initial boom of nutrient load and production is followed by a rapid decline of both, which is followed by a very slow increase in production and nutrient

load over a long period of time. In other words, after the dam closure, a phase of unbalanced eutrophy (five years) takes place, followed by a five-year phase "toward vulnerable stability" (increase in number of species). This is followed by another five-year phase of "securing stabilization", then by a six-year period of maturity, which changes into an unbalanced eutrophy phase under the impact of natural and man-made pollution (farm, and land run-off, sewage discharge).

I do agree with other reviewers that Balon's part is rather verbose, and presents the data in too much detail and in an excessive number of tables. I would welcome elimination of Appendix G, Lepidological study, and Part III, An annotated photographic summary of the Lake Kariba ecosystem, which would certainly reduce the price without harming the quality of the book. On the other hand, I would probably keep the ERTS satellite images of Lake Kariba as they are a useful reminder that one should use these services, which are dirt cheap for the value and accuracy provided.

In conclusion: Balon and Coche is a welcome contribution to our knowledge of large tropical man-made lakes. But it is not a review book, where one would expect synthesis of the current knowledge on the topic. It also misses some of the work done on the other side of the lake in Rhodesia. However, it will still remain the basic source of limnological knowledge on Lake Kariba, as intended by both authors. We would be glad to have such a book on Lake Argyle (Ord River).

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"THE INLAND WATERS OF TROPICAL AFRICA"

BY L.C. BEADLE

365 pp., 1974. Longman, London. Price: £7.00

REVIEWED BY T. PETR, MONASH UNIVERSITY

Beadle's book brings together for the first time the main aspects and problems of tropical African limnology. It is nicely written in clear English as it is aimed mainly at African universities' students.

The book can be arbitrarily subdivided into two parts. In the first the chapters deal with the history of African limnology, geology, climate of Africa, physics and chemistry of African waters, primary production, plants and animals. The second part discusses the major water bodies (or systems): the great rivers, Lakes Albert and Rudolf, Saharan water bodies, Lakes Chad, Edward, George, Victoria, volcanic barrier lakes and Lake Kivu, Lake Tanganyika and Lake Malawi. Tropical

swamps are dealt with in a separate chapter, as well as temporary, saline and thermal waters and Lake Chilwa. African man-made lakes are reviewed.

Leonard Beadle stresses that his book is not a comprehensive review of all the available information on the subject. It aims rather at presenting an outline of what can reasonably be inferred from the evidence about the origin and history of the tropical African inland waters and their faunas and floras, at describing what is known of the cycles of events in the different water systems, particularly in relation to organic production, and indicating the importance of these waters to the peoples of the area. The discussions have been conducted on a background of evolutionary concepts and limnological principals presented in the simplest manner. These principles were first established in relation to conditions in temperate climates, and their relevance to waters in the tropics is discussed.

The process of cichlid speciation certainly went berserk in lakes such as Victoria (177+ species), Tanganyika (214+ species), and Malawi (245+ species) where cichlids dominate the fish fauna. The African rivers are also rich in species, for example the Congo where so far 669+ fish species have been identified.

For over forty years Leonard Beadle studied tropical waters of Africa and America and worked on the physiology of animals in fresh and saline waters. He is a well-known authority on the tropical swamp environment. In Uganda, where he spent 16 years (1949-1964) as Professor of Zoology at Makerere, he was greatly interested in respiratory adaptations of papyrus swamp animals. His studies led him to state that "no animals have yet been shown to survive permanently in the complete absence of oxygen". However, this opinion seems to be overcome by the recent work of Fenchel and Riedl who in 1970 summarized information on invertebrates living permanently in the sulphide system which never has any oxygen.

Fish fauna appears to be much less manipulated in Africa than elsewhere. Thus the number of introductions is rather small, and in discussing the introduction of the Nile perch into Lakes Kioga and Victoria Beadle is tolerant of his conclusions, and does not appear to be much worried by the predatory impact of this fish on the endemic fauna.

I was glad to find a reference to Berns and Peters' (1969) paper on the fish Ctenopoma. Professor Peters and Sylvia Berns have been working on air breathing anabantid Ctenopoma for a number of years. Once they arrived in Uganda only several days before the Tanzania-Uganda confrontation. Shortly after departing on a sampling trip to Lake George they were rounded up with a number of tourists by the Ugandan Army, and transferred from Queen Elizabeth National Park to Kampala in army trucks. When they arrived at my house they had a colourful story to tell. In spite of that, they managed to collect and transport live specimens not only during their 'fully accompanied tour' from Lake George to Kampala, but also on the 'plane to Germany for further studies in the Tübingen's Institut für Verhaltensphysiologie.

In the last chapter of the book Beadle stresses the point that in dealing with a dynamic situation, i.e. a continuously changing environment, our knowledge will be continuously changing as well, and certain interrelationships between the categories may turn out to be

untenable or at least of limited application. He believes that tropical Africa offers the best research opportunity for studying the origin and evolution of lake ecosystems.

The book is neat and nicely set out with very well selected and beautifully drawn, clear figures. The number of references marked by an asterisk indicates the large number of scientists with whom the author was in direct contact during the process of writing. This feedback was undoubtedly extremely helpful and it could be considered as one of the factors which contributed to the high standard of this book.

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POSTSCRIPT

TROPICAL MAN-MADE LAKES - THEIR ECOLOGICAL IMPACT

Australian Fisheries 1976 November issue has updated our knowledge on what is happening in Lake Argyle: Silver cobbler (evidently a synonym of silver tandan, *Tandanus argenteus*) has proliferated and can now be exploited commercially. The lake will be stocked with giant perch (barramundi, *Lates calcarifer*) by Fish Farms International Ltd. This has been approved by the Western Australian government. However, it was stressed that the fish farming operation would not be allowed to affect the primary use of the main Ord dam. To guarantee non-interference with the stocking of the giant perch, no other commercial venture would be allowed on Lake Argyle for six years.

It will be a matter of interest to observe the impact on the giant perch on the native fish, especially the silver cobbler. The results might serve as guidance for other proposals in northern Australia, and also perhaps indicate what would happen if the African Nile perch *(Lates niloticus)* is introduced into some Australian tropical waters.

Ed. Note: This postscript was received after the Newsletter had been more or less completed hence its separate appearance in this space. It would otherwise have been omitted!

* * * * *

A.S.L. BUSINESS

MINUTES

SECOND EXECUTIVE COMMITTEE MEETING

George Bass Hotel, Kalimna, Vic. September 9, 1976

PRESENT: D. Pollard, F. Reynolds (Acting Secretary), K, Shearer, N. Ruello, R. Williams (acting for H. Burton), J. Lake.

APOLOGIES: K. Walker, D. Cannon, T. Hillman, R. Buckney, G. Ganf, R. Tilzey, L. Macmillan.

1. A draft agenda and the minutes of the previous meeting were circulated before the meeting; these were adopted without amendment.

2. Business arising from the minutes:

(a) NZLS Congress. Secretary-Treasurer reported on this meeting; a summary would appear in the Newsletter. Some members of NZLS expressed interest in attending an ASL Congress. Secretary-Treasurer is to keep them informed.

(b) Jolly Award. To date two nominations had been received. There would be a call for nominations in the next Newsletter.

(c) Library. The ASL Library is in the process of being transferred to Naranderra.

3. Correspondence:

(a) Secretary-Treasurer was instructed to write to the Australian Society of Plant Physiologists outlining arrangements for the next ASL Congress.

(b) A letter from B. Timms regarding the possibility of extending business sessions at future Congresses was discussed. It was felt that most members would find such arrangements unsatisfactory; not all were free of commitments at that time, and other conferences were held during the May vacation. Secretary-Treasurer was instructed to inform Dr. Timms of this decision, and to accept his offer to conduct an excursion on the Monday of the Congress weekend.

(c) The matter of AJMFR Referees (item 14e, 15th AGM) was discussed. The committee felt that policy in this matter should be left to the publishing body, and that ASL should not enter into any discussion with them. However, this should not precipitate the raising and elaboration of this item at a future AGM.

(d) Committee decided to accept the offer from the Chinese Scientific and Technical Information Centre for exchange of ASL Publications with the journal "Acta Hydrobiologica Sinica".

(e) H. Burton had suggested that a session on Antarctic Limnology be included in the next Congress. The Committee agreed, and appointed H. Burton as coordinator for this session; he should seek contributions from New Zealand workers.

(f) The sub-committee of the Editorial Committee looking into the proposal to produce a Memorial Book for Hilary Jolly had recommended against the proposal. The Executive Committee accepted this recommendation.

4. President's Report:

President reported on progress, and said that everything was O.K.

5. Secretary-Treasurer's Report:

Membership: Since May, the following had announced their retirement from the Society: L.M. Angel, L. Fox, E. Riek, M. Gray. With the addition of six new members, there are now 150 financial members and 92 unfinancial.

Finance: Balance in General Account $2,132.62
" " Publications Account 591.49

6. Newsletter Editor's Report:

Prof. Williams had reported that arrangements for printing the Newsletter had been made. Enquiries about providing a stiffer cover were continuing. He announced that papers presented at the recent ANZAAS conference symposium on reservoir biology were available for publication in the Society's Newsletter.

7. Editorial Committee Report:

There was little to report at this time. Members were preparing to look into the matter of Taxonomic Handbooks.

8. Limnological Symposium at the next ANZAAS Conference:

Dr. A. Martin, Joint Secretary of Section 11 (Zoology) for the next ANZAAS Conference had written asking if ASL would be prepared to organise a Symposium during the next ANZAAS meeting. The Committee felt that it could not undertake such a project, but suggested that Drs. I. Bayly and T. Petr might be available to coordinate a session of papers. (Both will be absent from Melbourne at that time - Sec.)

9. Association of Scientific Socities:

Committee discussed a letter from the Joint Secretaries of Section 11 of ANZAAS seeking views on the formation of an Association of Scientific Societies to coordinate the activities of societies and to provide liaison. The Committee decided to reproduce the letter in the ASL Newsletter, with a view to obtaining members' views, and to place the matter on the next AGM Agenda.

10. Contact with schools:

A proposal from R. Grandison was discussed fully. The Committee felt that the Society's resources at this time were not such as to justify the required output of manpower and money. It was felt strongly that a sub-committee of interested persons should be formed at the next AGM to coordinate and to liaise with sources of material and individuals. The Committee will recommend that all members cooperate fully.

11. XVI Congress:

J. Lake reported on organisation for the Congress. The Committee thanked him for his efforts. Details will be published in the Newsletter.

12. Other Business:

(a) D. Cannon had offered to travel to Lismore to help with Congress arrangements. The offer was accepted with thanks.

(b) The President drew attention to a consulting service to be set up by the American Fisheries Society. This will be reprinted in the Newsletter with a view to obtaining comments from members. This matter will be placed on the Agenda for the next AGM.

Meeting closed 1600 hours*.

* Ed. Note: In the rough transcript of the minutes there is an addendum to the time of closure. It read: "as the bar is now open".

XVI CONGRESS ARRANGEMENTS
LISMORE

DATES AND BROAD PROGRAMME

Friday, 20th May, 1977:
Arrival and registration

Saturday, 21st May, 1977:
Formal papers; annual dinner

Sunday, 22nd May, 1977:
Formal papers (to 10.30 a.m.)
A.G.M. (to 12.30)
Excursion and B-B-Q at rainforest and streams of "unique limnological interest"

Monday, 23rd May, 1977:
Optional day excursion to Lake Ainsworth and Taylor's Lake (Ballina-Byron Bay area).

FACILITIES

Available from College; lecture theatre; full range A-V equipment; closed circuit TV (not colour!); college radio (request may be made to retransmit some of the talks).

ACCOMMODATION

Benallong Motel (3-star). B&B Double $19.50, Single $14.50. Can accommodate about 60. $5 deposit/room required two months in advance. Final numbers required by mid-March.

Caravan Park. Near Town. Tentatively booked a few vans. Best numbers - 4 people in 6 berth, 2 in a 4 berth. Approximate cost $10 per night.

TRAVEL

Car

Airlines of N.S.W. Sydney to Casino, then bus to Lismore.

North Coast Airlines. Brisbane - Lismore - Newcastle.

ANNUAL DINNER

Workers Club (7.00 - 12.30 p.m.). Within walking distance of College. Move to make all conference delegates temporary members, and thus can make use of facilities at other times (e.g. counter lunch). Private room and service available for annual dinner (basic cost about $6/head).

PAPERS

Except for Hilary Jolly award and possible keynote address, papers to be 20 minutes. There will probably be an Antarctic limnology session, and maybe other sessions.

EXCURSIONS

Sunday afternoon to rainforest and streams by bus (cost $2/head) round trip 50 miles. B-B-Q 3.30 - 5.00 p.m. (lunch, sandwiches and cans on bus). Return to Lismore about 6.00 p.m.

Monday: Visit to Ainsworth and Taylor's lake (sand mining in the latter, former is dune lake) and Ballina-Byron Bay area. Transport by private car. Evening dinner at "Mexican Micks", Byron Bay.

REGISTRATION

Require numbers, particularly for accommodation, by mid-March. Please see and use insert form.

LETTERS

From Drs. F.H. Drummond and A.A. Martin, Department of Zoology, University of Melbourne (Joint Secretaries of ANZAAS, Section 11). [See Item 9 of Second Executive Meeting.]

Dear Dr. Buckney,

Over recent years there has been a marked increase in the number of societies of professional biologists which meet independently of ANZAAS Congresses. For this reason, and others, fewer and fewer of us attend these Congresses which, as far as biologists are concerned, no longer fulfil the objective "of bringing together scientisits of all types and occupations so that they may interchange information and ideas".

From several sources we have received suggestions that this important objective could be achieved by an association of specialist societies on the lines of the American Institute of Biological Sciences. The major function of such an association would be to organise annual scientific meetings involving all the member societies.

If there is sufficient interest in this proposal, the Committee of Section 11 (Zoology) would arrange for a discussion to be held at the ANZAAS Congress in Melbourne next year.

We would be pleased to hear, at your earliest convenience, whether representatives of your Society would take part.

-ooOoo-

From Christine Settle, Acting Director, Australian Heritage Commission, 1st Floor, John Curtin House, Basten, A.C.T. [Nomination forms are available from Dr. David Pollard, N.S.W. Fisheries]

REGISTER OF THE NATIONAL ESTATE

The Australian Heritage Commission is now calling for nominations for sites and areas to be included in the Register of the National Estate. A background paper on the development of the Register is attached for your information.

The Commission is acutely aware that success in establishing the Register is to a significant degree dependent on the goodwill and scarce resources of bodies such as your own.

In South Australia and Tasmania the State Government is establishing a committee of state government agencies and conservation groups to coordinate nominations in order to reduce costs and avoid duplication of effort. Conservation groups are free to make nominations independently of this committee, if they wish to do so.

A list of organisations in each State receiving nomination forms is included in Attachment 2. The Commission intends to circulate nomination forms more widely when the initial Register is established.

Officers of the Commission staff will visit all states and territories in the first half of November to assist in completing nomination forms.

The Commission looks forward to working with you in its task of identification, protection and presentation of the National Estate.

REGISTER OF THE NATIONAL ESTATE - BACKGROUND INFORMATION

Under the Australian Heritage Commission Act 1975 the Australian Heritage Commission is required to establish and keep a register of places included in the National Estate.

The Act defines the National Estate as consisting of those places being components of the natural environment of Australia, or the cultural environment of Australia, that have aesthetic, historic, scientific, or social significance, or other special value for future generations as well as for the present community. For the purposes of the Act Australia includes all external Territories, the territorial sea of Australia, and the continental shelf of Australia.

To assist the Commission in establishing the Register nominations are being sought from relevant bodies and interested individuals throughout Australia. The Commonwealth Government has requested the Commission to have the Register well advanced by June 1977 to provide a basis for development of a program for the protection, preservation, and presentation of the National Estate. If a substantial register is to be achieved by this date it is important that nominations for as many places as possible be received by the Commission by 31st DECEMBER 1976. Submissions will of course be accepted after this date, as the compilation of the Register will be an ongoing process; however, it is doubtful that nominations received after 31st December could be placed on the Register in time for consideration in drawing up the 1976/77 budget.

We would like to receive nominations for the most significant places first to be sure that the first listings include the places considered by the nominators to be unequivocally part of the National Estate. We would however like to make clear that there will be no gradings on the Register and those places submitted and accepted later will have the same status as places which have been considered first.

The following points might be noted:

- Registration of places is an ongoing process and nominations will be accepted at any time.
- National Parks and other government reserves, and buildings classified by the National Trusts will in general be nominated by the government bodies and Trusts concerned. If there is any doubt that this will occur in particular cases, a check should first be made with these bodies before nominating the site. This will avoid duplication of effort.

- Similarly, checks should be made in the case of places that have governing boards, trustees, etc., to avoid or reduce duplication of nominations.

- If for any reason the nominator considers that by registration a place might become threatened, the matter should be discussed with a suitable State Government body or voluntary society and/or with Commission staff. The nature of the threat should be clearly defined on the nomination form so that the Commission may consider suitable means to avert this threat.

- For the purpose of this initial listing the Commission will be relying heavily on assessments of the value of a nominated place previously made by recognised experts or expert bodies.

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AMERICAN FISHERIES SOCIETY

(See Item 12b in Minutes of Second Executive Meeting)

— ATTENTION RETIRED AND RETIRING AFS MEMBERS —
AN AFS CONSULTING SERVICE?

In the past few years the use of professional consultants in the field of aquatic sciences has expanded several times. This is true for business, industry, and governments. Though primarily a North American development, a growing interest is also being evidenced in Europe and in the wealthier developing nations. The proliferation of environmental problems and the tremendous competition for the use of limited water supplies will assure that this consultant need is more than a passing fad.

The American Fisheries Society has roughly 5,500 professional members. Every year from 100 to 200 of these members take voluntary retirement or are forced by employer policy to quit when they reach the designated retirement age. Collectively, these retired members represent a vast reservoir of fisheries science knowledge with thousands of years of invaluable practical experience. Many retired professionals have not only excellent health but a continuing passion for work and the same keen curiosity that led them to become successful scientists. Many also need to work, for they are finding that savings and retirement programs established in an era of less inflation and lower wages are not adequate to meet today's costs.

The American Fisheries Society is investigating the feasibility of organizing interested retired members into a system of consultants and consultant teams. For legal purposes the organization would be incorporated and might adopt a name such as American Fisheries Society Consultants Inc. Details of operation are very sketchy but initial coordination might be provided by one or two volunteer members with assistance from the AFS central office.

The 105-year-old American Fisheries Society has tradition, a positive identity, and an excellent reputation in the aquatic sciences community. It is a logical, believable source for fisheries science services. The professional experience available through an organization of retired AFS members would be unmatched anywhere in the world. Such an organization could make important contributions to society, could give members the continuing scientific challenge and opportunity for service so basic to the "good life," and could provide additional, often needed income for retired members.

If you are a retired AFS member or will be retiring within the next two years, we ask that you complete this tear-out questionnaire and submit it to the AFS central office. If sufficient interest and response is received we will press on with the idea, and some type of regular communication will be devised to keep you informed.

AMERICAN FISHERIES SOCIETY
Consultant Registry

I wish to have the following professional information entered in the Registry to indicate my training, experience, and interest in consulting on certain fisheries and related aquatic subjects.

Name: _____ Date of Birth: _____

Address: _____ Physical Limitations: _____

_____ _____

_____ _____

Now Retired _____ yes _____ no Date you will retire: _____

Willingness to travel: _____

Telephone _____

Education
(Degree, school year)

_____

_____

_____

_____

(Major subjects)

_____

_____

_____

- Employment -

(List professional assignments, your title, name and address of employer and years on job)

_____

_____

_____

_____

_____

- Subjects of Professional Competence -

(Please circle appropriate items adding others as needed)

Fish Culture .... hatchery design, hatchery operation, disease control, nutrition, breeding, marketing, _____ other

_____ other, _____ other

Aquatic environments .... warm, cold, intermediate, reservoir, lake, pond, river, stream, marine, estuary.

Fisheries Management .... population manipulation, reclamation, species introduction, harvest regulation, habitat improvement, vegetative control, _____ other, _____ other, _____ other

Research .... aquatic insects, crustacean, parasites, algae, rooted aquatics, reptiles, amphibians, physiology, water chemistry, power plants, spawning, migration, population dynamics, _____ other, _____ other, _____ other, _____ other

Environmental Degradation .... siltation, channelization, oil and gas development, surface mining, deep mining, sewage effluent, industrial wastes, thermal effluents, water diversion, timber harvesting. _____ other, _____ other

_____ other

Environmental Impact Statements .... prepared, reviewed, evaluated.

Administrative Evaluations .... fisheries, training, research, management organizations, management effectiveness, _____ other

_____

Geographic Familiarity .... (List regions and river basins most familiar to you)

_____

_____

_____

Species or Species Groups in which you specialize .... _____

_____

_____

_____

Non-English Language Competence ...

Language	Reading Knowledge	Speaking	Writing
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Additional Comments .... _____

_____

_____

I am (willing) (unwilling) to present testimony at hearings and trials if accepted by all sides as an expert witness.

I am (willing) (unwilling) to divulge all potential conflicts of interest that may arise from my past and present employment, present stock holdings, and current land and real estate ownerships.

Mail to
American Fisheries Society
5410 Grosvenor Lane
Bethesda, Maryland 20014

Signature: _____

Date: _____

Ed. Note: Quite why the Executive wanted the above matter reprinted in entirety in the Newsletter, I am at a loss to understand! However, I am but a servant of the Executive.

AUSTRALIAN WATER AND WASTEWATER ASSOCIATION

SEVENTH BIENNIAL CONVENTION

CANBERRA SEPTEMBER 21-24, 1977

The Australian Water and Wastewater Association is holding its Seventh Biennial Convention in Canberra from September 21-24, 1977. The Convention theme will be 'Public Aspirations and Realities in Water Resources Manangement' and within the broad theme papers will cover the following topics -

- Public participation
- Advances in treatment methodology and standards
- Advances in laboratory technology
- Operator training
- Planning for integrated water resources development
- Demand management, including engineering and economic considerations

All correspondence relating to the convention to:-

Mr. F.C. Speldewinde,
Convenor,
AWWA Seventh Biennial Convention,
P.O. Box 359,
CANBERRA CITY, A.C.T. 2601.

One of the features of the Seventh Biennial Convention will be a technical tour of the Lower Molonglo Water Quality Control Centre.

Effluents from wastewater treatment plants in Canberra discharge to the Molonglo and Murrumbidgee Rivers and investigation has shown that the concentration of biostimulants such as phosphorous and nitrogen in the river systems is showing a general increase compatible with the growth of population in Canberra. Levels of phosphorous during the spring of 1972 reached an average level of 0.43 mg/l with concentrations of 1.4 mg/l during summer 1972-3. These concentrations of biostimulants have resulted in significant growth of long filamentous algae attached to rocks in the river bed with large mats of algae occurring during drought periods.

The National Capital Development Commission has recognised the significance of the biostimulants present in effluent discharged from the existing treatment plants in Canberra and during 1970 authorised the Department of Construction to undertake the design and construction on its behalf of a major treatment facility designed to achieve the following effluent standards:

(a) Substantially free of settleable solids or floatable solids, turbidity, colour and odour
(b) BOD-, and suspended solids concentrations both less than 5 mg/l.
(c) Free of toxic substances
(d) Median faecal coliform concentration of less than 50 per 100 ml
(e) A nitrogen concentration of less than 2 mg/l and a phosphorous concentration of less than 0.15 mg/l.
(f) Detergent concentrations of less than 0.5 mg/l M.B.A.S.

The plant has been planned for four possible stages to cater for a population of up to one million persons. The first stage of the plant has been designed for an average dry weather flow of 109 Ml/day. The plant will provide primary screening followed by solids separation with lime additions for phosphorous removal, biological nitrification and clarification, followed by biological denitrification using methanol in fixed growth reactor columns, effluent filtration and chlorination prior to discharge to the Molonglo River. Sludge will be classified to recover lime by recalcination followed by incineration. Following commissioning of LMWQCC the Weston Creek and Tuggeranong plants will be decommissioned.

* * * * *

ENVIRONMENTAL ENGINEERING CONFERENCE, 1977

CANBERRA, JUNE 16-18, 1977

The National Committee on Environmental Engineering of the Institution of Engineers, Australia, is planning its fourth national conference, which will be held in Canberra from JUNE 16-18, 1977.

The Conference Theme will be "THE POLITICS, ECONOMICS AND TECHNOLOGY OF POLLUTION CONTROL".

Papers will deal in particular with all aspects within the theme which, in its broader understanding, poses the specific questions -

- Should International, National, State or Local criteria - standards, regulations and laws - on pollution control be harmonised?
- Is this politically, economically or technically feasible?

Further information relating to the Conference is available from the Institution's Conference Manager.

Environmental Engineering Conference, 1977
The Institution of Engineers, Australia,
Science House,
157 Gloucester Street,
SYDNEY, N.S.W. 2000.

INTERNATIONAL ASSOCIATION ON WATER POLLUTION RESEARCH

SPECIALIZED CONFERENCE ON

RIVER BASIN MANAGEMENT

WHERE: Headquarter of Ruhrverband and Ruhrtalsperrenverein,
Kronprinzenstr. 37,
D-4300 Essen 1,
FR Germany.

WHEN: 12 - 16 September, 1977.

SPONSORS: The International Association on Water Pollution Research (IAWPR)

Abwassertechnische Vereinigung (ATV)

Emschergenossenschaft and Lippeverband

Ruhrverband and Ruhrtalsperrenverein

ORGANIZERS: The conference is being arranged by Emschergenossenschaft and Ruhrverband

OBJECTIVES: The conference shall provide a forum to exchange experience and practical information on technical, economical, institutional and legal aspects of River Basin Management on an international basis. This topic has been selected since the necessity of optimal water pollution control by a systemwide water management is discussed all over the world.

The number of participants is limited to about 120 in order to stimulate a fruitful exchange of experience.

Papers are focussed on present-day problems and solutions and are based on practical experience in River Basin Management.

REGISTRATION FEE: The conference registration fee is 160 US dollars for IAWPR members and 200 US dollars for non-members.

Registration fee for ladies is 20 US dollars.

ENQUIRIES AND INFORMATION: K. R. Imhoff,
Director of Ruhrverband and Ruhrtalsperrenverein,
Kronprinzenstr. 37,
D-4300 Essen 1,
FR Germany.

SUSTAINING MEMBERSHIP

The Society acknowledges with gratitude the support of:

GUTTERIDGE, HASKINS & DAVEY

Consulting Engineers, Planners, Surveyors,
380 Lonsdale Street, Melbourne, Vic. 3000.

G.H. & D. is an established firm of consulting engineers, with a total staff of some 600 people, including planners, architects, surveyors, hydrologists and engineers. The firm has 17 permanent officers throughout Australia, and rightly claims to be one of our largest multi-disciplinary consulting organisations.

DEPARTMENT OF ZOOLOGY

University of Adelaide, G.P.O. Box 498,
Adelaide, S.A. 5001.